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AUTHOR Ellington, Henry
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ABSTRACT

The first of three sequels to the booklet "Student Assessment," this booklet begins by describing and providing examples of four different forms that objective questions can take: (1) conventional multiple choice questions; (2) true/false questions; (3) assertion/reason items; and (4) matching items. Guidance is offered on how to decide which type of question to use in a given situation, and on how to write objective questions of different types. Methods for evaluating objective questions are then discussed, including evaluation by a colleague or validation panel and quantitative evaluation. Advice on how to mark objective questions concludes the booklet. Three general references and three subject-based references for teachers of chemistry, physics, and mathematics are recommended for further reading. (MES)

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Objective Questions

Introduction

This booklet forms a sequel to booklet number 20 in the series, 'Student assessment', which presents a broad survey of the field and examines the different assessment techniques that can be employed therein. The present booklet deals in more detail with one particular group of assessment instruments, namely, questions of the *objective question* type.

The booklet begins by examining the different forms that objective questions can take and offering guidance on how to decide which type to use in a given situation. Next, it gives detailed guidance on how to write objective questions of different types. Finally, it offers practical advice on how to evaluate and mark objective questions.

The different types of objective question

As is pointed out in the booklet on 'Student assessment', *multiple-choice questions* are the most commonly used type of objective question, their main characteristic being that they provide a selection of alternative answers from which the testee has to choose rather than requiring the testee to supply the answer him/herself. Thus, such questions can be marked with *complete reliability* by anyone – or even, in some cases, by computer – since no interpretation or evaluation of the answers is required. Let us now look at some of the most common forms that objective questions can take.

'Conventional' multiple-choice questions

By far the most widely used type of multiple-choice question is what we may describe as the 'conventional' multiple-choice question. This consists of a simple question or incomplete statement (the *stem*) and four or more possible answers or completions, one of these being correct (the *key*) and the others being incorrect (the *distractors*). Examples of the two basic forms are given on the next page.

Example 1 (stem in the form of a question)

What is the combined resistance of three 6 Ω resistors connected in parallel? STEM

(a)	18 Ω ☐	DISTRACTOR
(b)	3 Ω ☐	DISTRACTOR
(c)	2 Ω ☐	KEY
(d)	6 Ω ☐	DISTRACTOR

Example 2 (stem in the form of an incomplete statement)

All the atoms of a particular chemical element have the same STEM

(a)	number of neutrons in their nuclei ☐	DISTRACTOR
(b)	number of protons in their nuclei ☐	KEY
(c)	number of nucleons in their nuclei ☐	DISTRACTOR
(d)	number of positrons in their nuclei ☐	DISTRACTOR

In both the above cases, the testee indicates the answer chosen by marking the appropriate box.

True/false questions

Another widely used type of objective question is the *true/false question*, consisting of a statement which the testee has to indicate to be 'true' or 'false'. Such questions are often presented in the form of a series covering different aspects of the same topic, as in the example shown below.

Example of a linked series of true/false questions

Delete either the word **TRUE** or the word **FALSE** after each of these statements to indicate whether you think it is incorrect or correct.

(i)	Granite is an example of a plutonic igneous rock	TRUE/FALSE
(ii)	Granite has an aphanitic texture	TRUE/FALSE
(iii)	The essential minerals in granite are quartz, felspar and mica	TRUE/FALSE
(iv)	The total SiO_2 content of granite is generally in the range 65–80%	TRUE/FALSE
(v)	Granite has well established cleavage planes	TRUE/FALSE
(vi)	Granite sometimes contains fossils	TRUE/FALSE
(vii)	Granite is highly resistant to weathering	TRUE/FALSE

(Note: of the above, (i), (iii), (iv) and (vii) are *true* and (ii), (v) and (vi) are *false*)

Assertion/reason items

These are variations on the basic 'true/false' question form, each item consisting of an ASSERTION (given on the left) linked to a REASON (given on the right). The testee has to decide whether the assertion and reason are individually correct or not, and, if they are both correct, whether the 'reason' is a valid explanation of the 'assertion'. The answer is usually indicated by marking each item 'A', 'B', 'C', 'D' or 'E' according to the following code:

A: both the assertion and the reason are true statements and the reason is a correct explanation of the assertion.

B: both the assertion and the reason are true statements, but the reason is NOT a correct explanaton of the assertion.

C: the assertion is true but the reason is false

D: the assertion is false but the reason is in fact a true statement in its own right

E: both the assertion and the reason are false

Three examples of assertion/reason items are given below

Examples of assertion/reason items

	ASSERTION		REASON	
(i)	Carbon 14 undergoes β^- decay	BECAUSE	It has too many neutrons in its nucleus to be stable	☐
(ii)	Sodium reacts readily with most non-metals	BECAUSE	It is highly electro-negative	☐
(iii)	Reduction of interest rates tends to reduce inflation	BECAUSE	It increases the amount of money in circulation	☐

(Note: the correct responses to (i), (ii) and (iii) are respectively A, C and D)

Matching items

A fourth common type of objective question is the *matching item, or matching block*. Typically, this consists of two lists of statements, words, or symbols which have to be matched one with another. In general, the two lists contain different numbers of items, those in the longer list that do not correspond to items in the shorter serving the function of distractors. Two of the forms that such matching items can take are given below.

Example 1 (a 'conventional' matching item with the second list containing the 'answers')

For each country in Column A, select the capital city from Column C and write it in the appropriate space in Column B		
A. *Country*	**B.** *Capital City*	**C.**
France		Warsaw
Spain		Oslo
Belgium		Copenhagen
Norway		Belgrade
Sweden		Budapest
Switzerland		Berlin
Italy		Paris
Hungary		Moscow
Russia		Prague
Czechoslovakia		Brussels
		Madrid
		Lisbon
		Berne
		Stockholm

Example 2 (a 'reversed' matching item with the first list containing the 'answers')

Sub-atomic particles have different properties. Match the names of the following particles with their properties by writing the letter representing the particle against its properties.

Name of particle	*Properties*
A. proton	1. ☐ rest mass 106 MeV; charge + 1; spin $\frac{1}{2}$
B. neutron	2. ☐ rest mass 0.5 MeV; charge - 1; spin $\frac{1}{2}$
C. π^+ meson	3. ☐ rest mass 939 MeV; charge 0; spin $\frac{1}{2}$
D. μ^+ meson	
E. electron	4. ☐ rest mass 137 MeV; charge + 1; spin 0
F. positron	
G. neutrino	5. ☐ rest mass 0 MeV; charge 0; spin $\frac{1}{2}$

(note: the answers are 1: D; 2: E; 3: B; 4: C; 5: G)

A large number of variations on these different question types are, of course, possible, e.g. basing a series of objective questions on a map, diagram, table, etc.

Deciding which type of question to use in a given situation

As was shown in the booklet on 'Student assessment', objective questions are best suited for assessing learning outcomes in the lower-to-middle part of the cognitive domain, i.e. for testing *knowledge*, *comprehension*, *application* and (to a lesser extent) *analysis*. They are not particularly well suited for testing *synthesis* and *evaluation* (the highest levels of the cognitive domain), nor are they really suitable for testing non-cognitive skills such as communication skills, interpersonal skills and psychomotor skills. Thus, the first thing that anyone thinking of making use of objective questions should do is check that the learning outcomes that he wishes to assess are in fact suited to this form of assessment; if they are not, he should employ some other assessment technique (see booklet on 'Student assessment' for the various alternatives).

Assuming that an objective question approach is felt to be appropriate, the next thing that must be decided is which particular type (or types) of item should be used. Here, the best approach is probably to draw up a detailed list of the various topics and skills that are to be tested and then look at these individually, selecting the type of item that you feel would be most appropriate in each case. When matching item types to topics and skills in this way, it is often a good idea to start by considering the possibility of using a 'conventional' multiple-choice question (the most versatile and probably the most useful type), only switching to another type of item if the nature of the subject matter or skills to be tested strongly indicates that this should be done. Nor should the choice necessarily be restricted to questions of the objective question variety, since there may well be situations where it would be more appropriate to use a question of the *short-answer* type, e.g. where the ability to *supply* the answer is felt to be a significant factor in the assessment (see booklet on 'Short-answer questions' for detailed information about this type of assessment item).

Needless to say, full use should be made of any suitable 'ready-made' items (e.g. items held in a central *item bank*) when designing an objective test. Producing good, properly-validated objective items is a highly-demanding and time-consuming business (*much* more so than producing good short-answer or essay-type questions), so you should only write your own if items of the type you want cannot be obtained 'off the shelf'. Conversely, once you have taken the trouble to produce a good objective item, it is almost certainly worthwhile lodging it in a bank of some sort so that it is readily available for future use.

How to write objective questions

Let us now look at how to set about the task of writing objective items of different types. Only the two basic forms – *'conventional' multiple-choice questions* and *true/false questions* will be discussed, since all other types can be thought of as variations of these. *Assertion/reason items*, for example, can be thought of as complex true/false questions, while *matching items* can be thought of as interlocking systems of 'conventional' multiple-choice questions.

Writing 'conventional' multiple-choice questions

The process of writing a 'conventional' multiple-choice item can be divided into four stages.

Stage 1: determining the overall purpose and content of the item

This is a continuation of the process that was described in the previous section, and involves:

- identifying the topic that is to be covered by the item (generally a specific topic from a syllabus of some sort);
- identifying the specific learning outcomes or skills that are to be assessed by the item (generally either *knowledge*, *comprehension*, *application* or *analysis*, or some combination of these).

Stage 2: writing the stem

The *stem* is the most important part of any conventional multiple-choice question, so great care should be taken in its design, observing the following basic rules:

- Use the stem to present a single, clearly-formulated problem – a problem that should be clear to the testee *without* reading the alternative answers supplied. (Indeed, a good method of checking the clarity and completeness of an item is to check whether it can be answered by a good student without the answers being available.)
- Express the stem in clear, simple language, making it as concise as possible and avoiding any possibility of ambiguity or misinterpretation. Remember that the purpose of a good-multiple choice question should be to assess knowledge and skills related to the subject matter covered, *not* to assess the testee's ability to decipher the question.
- Put as much of the wording of the question as possible into the stem, so that the answers supplied can be as short as possible (this makes it easier for the testee to read and understand the question).

- Express the stem in positive form wherever possible, since it has been found that positively-phrased test items tend to measure more important learning outcomes than negatively-phrased items. (Knowing such things as the *best* method or the *most relevant* argument generally has greater educational significance than knowing the *poorest* method or the *least relevant* argument.)
- If you *have* to use negative wording in the stem of a question, use some form of emphasis (e.g. italics, bold type, capitals or underlining) to bring this to the attention of the testee.

Newcomers to writing multiple-choice items may find the following lists of standard stem types useful when assessing different aspects of the *knowledge* area of the cognitive domain (the area where conventional multiple-choice items are probably of greatest use).

Knowledge of terminology

- What word means the same as . . . . . ?
- Which statement best defines the term . . . . . ?
- In the following context, what is the meaning of the word . . . . ?
- What is . . . . . (some process) . . . . . called?

Knowledge of specific facts

- Where would you find . . . . . ?
- In what year did . . . . . ?
- Who first discovered . . . . . ?
- What is the name of . . . . . .?
- What is the most important characteristic of . . . . . ?
- What is the main difference between . . . . . ?

Knowledge of conventions

- What is the correct form for . . . . . .?
- Which one of the following symbols is used to represent . . . . .?
- Which statement indicates correct useage of . . . . . .?
- Which one of the following rules applies to . . . . . .?
- Which one of the following methods is commonly used to . . . . ?

Knowledge of trends and sequences

- Which one of the following best describes the present trend of . . . . . ?
- What is the most important cause of . . . . . .?
- What will be the effect of . . . . . ?
- What would be the shape of a plot of . . . . . .?

- Which one of the following sequences indicate the proper order for . . . . . ?

Knowledge of classification and categories

- What are the main types of . . . . . ?
- What are the major classifications of . . . . . .?
- What are the characteristics of . . . . . .?
- How would you classify . . . . . ?
- Which one of the following is an example of . . . . . .?

Knowledge of criteria

- Which one of the following is a criterion for judging . . . . . .?
- What criteria were used by . . . to judge . . . . .?
- What is the most important criterion for selecting . . . . .?
- What criteria are used to classify . . . . . .?
- Which one of the following is NOT an important criterion for . . ?

Knowledge of methodology

- What method is best for . . . . . ?
- What is the best way to . . . . . .?
- What would be the first step in making . . . . . ?
- What is the most important difference between the . . . . . and the . . . . . method?
- Which of the following would be essential in making . . . . . .?
- What would be the minimum equipment needed to . . . . .?

Knowledge of principles and generalizations

- Which statement best expresses the principle of . . . . . .?
- Which statement best summarizes the belief that . . . . . .?
- Which one of the following principles best explains . . . . . .?
- Which one of the following principles is most useful in predicting . . . . .?
- Which one of the following illustrates the principle of . . . ?

Knowledge of theories and structures

- Which statement is most consistent with the theory of . . . . ?
- Which principle is essential to the theory of . . . . . .?
- Which one of the following is the most complete formulation of . . . . . .?
- Which one of the following best describes the structure and organization of . . . . . ?
- Which evidence best supports the theory of . . . . . ?

Stage 3: writing the alternative answers

The second essential component of a 'conventional' multiple-choice item is the selection of possible answers that is supplied to the testee. These should normally be at least four in number, and should again be very carefully written observing the following basic rules.

- Make sure that all the alternatives are grammatically consistent with the stem of the item. Also, make sure that they all have the same grammatical form. (If this is not done, the testee may inadvertently be provided with help in choosing the correct answer, by, for example, noting that one or more of the distractors are inconsistent with the stem.) Two obvious steps that can be used to avoid such grammatical inconsistency are avoiding mixing singular and plural items in the answers, and avoiding using the indefinite article ('a' or 'an') as the last word of the stem.
- Make sure that the KEY (the correct answer) is unquestionably correct or (in the case of an item where the testee is asked to select the best or most appropriate answer) is unarguably the best or most appropriate of the options given. In a question of the latter type, it may also be necessary to include the words 'of the following' in the stem in order to allow for the fact that there may be equally satisfactory answers which have not been included in the item., e.g. 'which of the following is the best method for . . . . .?'
- Make sure that *all* the DISTRACTORS (the incorrect answers) are plausible and attractive to testees who are unfamiliar or only partly familiar with the material being assessed. A distractor which is so implausible that it is seldom if ever selected even by the poorest students is known as a *non-functioning distractor*, since it might as well not be there. Some basic steps that can be taken to increase the plausibility and attractiveness of distractors include the following:

  (i) Use the common misconceptions, or common errors, of students as distractors.
  (ii) State the various alternatives in the language of the students.
  (iii) Use 'good-sounding' words (e.g. 'accurate', 'important', etc) in the distractors as well as in the key.
  (iv) Make the distractors similar to the key both in length and in complexity of wording.
  (v) Use extraneous clues in the distractors, e.g. stereotyped phrasing, 'scientific'-sounding answers and verbal associations with the stem of the item. Do not overdo these clues, however.

(vi) Make all the alternatives as similar in form as possible.

- Avoid the use of the options 'all of the above' or 'all of these', and use the options 'none of the above' or 'none of these' only in exceptional circumstances. (It is not unusually important to know what something 'is not'; it is generally more important to know what something 'is'.)

Stage 4: finalising the layout of the item

Once you have written the stem and a set of appropriate alternative answers, some care should be taken in planning the final layout of the item. Again, a number of basic rules should be observed.

- Make sure that the item is presented in such a way that the testee is under no doubt as to what he is expected to do and how he is expected to indicate his chosen answer (e.g. by marking the appropriate box or ringing the appropriate letter or figure).
- Vary the position of the key in a random manner, so that the testee cannot obtain clues by detecting a pattern of any sort. Do not, for example, always place the key in one of the central positions. Some methods of avoiding this problem include listing the various options in alphabetical order, in order of length, in order of size (in the case of numerical answers), and so on.

Writing true/false questions

These are somewhat simpler to write than 'conventional' multiple-choice questions, but a number of basic rules should still be observed.

- Include only *one* central, significant idea in each statement. This main point should be an important one, and should occupy a prominent position in the statement. Also, the true/false decision should clearly depend on this key point and not on some subordinate point or trivial detail. The use of several ideas in a given statement should be avoided (unless they are intimately related) because these tend to be confusing, as well as giving rise to validity-related problems in many cases.
- Word the statement in such a way that it is either unquestionably true or unquestionably false, so that a student who is familiar with the subject matter will have no difficulty in deciding which is the case. This requires the use of words that are both definite and precise, and the avoidance of vague terms such as 'seldom', 'sometimes', 'often' or 'frequently'.

- Keep the statements as short as possible, and use a simple language structure. Long involved statements (especially those that include subordinate or qualifying material) can again give rise to validity-related problems (testing the student's ability to interpret the question rather than his or her knowledge of the subject matter).
- Use negative statements only in exceptional circumstances, and NEVER use double negatives. All negatives tend to confuse the reader of a question, and double negatives are especially bad in this respect. If a negative MUST be used, bring it to the attention of the testee by use of italics, bold type, capitals, underlining or something similar.
- Avoid statements of opinion unless these can be attributed to some source with which the students should be familiar.
- Avoid unwittingly providing clues to the learner by the form of wording of the statement. Statements which include such absolutes as 'always', 'never', 'all', 'none' and 'only' tend to be false, for example, while statements that include qualifiers such as 'usually', 'may' and 'sometimes' tend to be true.
- When designing a series of true/false questions, make sure that the numbers of 'true' and 'false' statements are roughly equal, and that no obvious pattern in the use of the two types can be detected. The latter problem can best be avoided by employing a completely random placement pattern, e.g. by basing the placement on a computer-generated random sequence of binary digits (e.g. 1 = 'true'; 0 = 'false') or on a table of random numbers (e.g. even numbers = 'true'; odd numbers = 'false').

How to evaluate objective questions

Once you have written what you think is a good objective question, it is always a good policy to have it evaluated in some way *before* you use it for the purpose for which it has been designed – especially if it is to be used in a formal test or examination of some sort rather than in a more informal setting such as a diagnostic test. They way in which this evaluation is carried out will, of course, depend on the circumstances, and can be anything from simply asking a colleague to read through the item in order to see if it 'looks OK' to organising a full-scale pre-trial and carrying out a rigorous statistical analysis of the results.

Having an item evaluated by a colleague or validation panel

The most common method of evaluating an objective question is to have it checked by a colleague or validation panel. In order to enable such an evaluation to be carried out in a meaningful and systematic way, it is advisable to present the item on a standard pro-forma of some sort – a pro-forma that not only gives the full text of the item, including the solution and (if appropriate) the marking scheme, but also states:

- the course, module, syllabus, etc. that the item relates to;
- the purpose for which the item is to be used;
- the particular topic that the item relates to;
- the particular educational skills or outcomes that the item is designed to assess (e.g. knowledge, comprehension, application, etc.);
- the intended level of difficulty, expressed either qualitatively (e.g. 'extremely easy', 'moderately easy', etc) or quantitatively (e.g. 'expected success rate 70%).

It should also state the name of the originator of the item and the date of production.

Ideally, the colleague or validation panel carrying out the evaluation should also be provided with an appropriate pro-forma on which to note their conclusions. This should ask for the following information about the item:

- Is the item relevant to the course/module/syllabus to which it relates?
- Is the item style appropriate to the topic being covered and the specific educational skills or outcomes being assessed?
- Does the item present the testees with a clearly-defined task?
- Is the item logically and structurally sound?
- Is the item stated in simple, clear language?
- Is the item free from extraneous clues?
- Is the stated difficulty of the item likely to prove accurate?
- Is this stated difficulty appropriate?

In the case of a 'conventional' multiple-choice question, the evaluators should also be asked:

- Is the key unquestionably correct or unquestionably the best available answer?

- Are all the distractors (a) compatible with the key?
  (b) unquestionably incorrect or unacceptable?
  (c) sufficiently plausible?

Obviously, any weaknesses or deficiences identified by the evaluation process should be remedied before the item is put to use – after being subjected to further evaluation, if necessary.

Carrying out a quantitative evaluation of an objective item

This can either be done *before* the item is used (by organising a pre-trial with a sample of the population for whom it is designed) or *after* the item has been used (by analysing the responses to the item in the test or examination in which it was incorporated). Whichever method is used, three pieces of information about the item should be obtained in the case of a 'conventional' multiple-choice question (the type that is most frequently subjected to quantitative analysis of this nature):

(i) The *facility value* (or *difficulty index*), which measures the degree of difficulty of the item. This is simply the fraction of testees who select the key. As was stated in the booklet on 'Student assessment', it should normally lie between 0.35 and 0.85, with the exact value depending on the purpose for which the item is designed and the intended degree of difficulty.

(ii) The *discrimination index*, which measures the degree to which the item separates the better students from the poorer students. This can be determined in a number of ways, e.g. by calculating the difference between the facility values for the top third of the population (for the test as a whole) and for the bottom third (again for the test as a whole) for the item under consideration. As was stated in the booklet on 'Student assessment', the discrimination index should always be greater than +0.2, and, for a 'good' item, should be at least +0.3.

(iii) The *plausibilities of the various distractors*, as measured by the percentages of the testees who select each. No distractor should attract less than 5% of the responses if it is to be effective.

Clearly, any weaknesses in an item that are brought to light by such an analysis (e.g. an inappropriate facility value or discrimination index, or evidence that one or more of the distractors are not effective) should be remedied before the item is used again. Indeed, if the analysis reveals that the item is a really bad one (e.g. has a

negative discrimination index) it should either be completely re-written or discarded.

In the case of a true/false question, a similar analysis can be carried out. Here, the two criteria that are of interest are again the *facility value* and the *discrimination index*, both of which can be determined in exactly the same way as for a 'conventional' multiple-choice question. The acceptable values of the two criteria will depend on the purpose for which the question is designed and the intended degree of difficulty, but, for a 'good' true/false question, the facility value should differ significantly from 0.5 (the value produced by pure guessing on the part of all the testees) while the discrimination index should again be greater than about +0.2.

How to mark objective questions

By their very nature, objective questions are extremely easy to mark, since they require no subjective interpretation of the responses by the marker. All that is required is a clear indication whether a response is correct or incorrect, e.g. by using a red pen to mark the correct responses with 'ticks' and the incorrect responses with 'crosses'.

When it comes to assessing the significance of the overall score gained by a testee in an objective item, however, the situation is not quite so simple and clear-cut. This is because it is perfectly possible for a candidate to gain a significant proportion of the available marks purely by guessing – a proportion that varies from 25% for a paper composed entirely of 'conventional' multiple-choice questions each of which has four options to 50% for a paper composed entirely of true/false questions.

If an objective test is being used purely for ranking purposes, experience has shown that there is little or nothing to be gained by scaling the marks down in order to allow for the above 'guessing factor'. The raw scores nearly always produce the same rank order as corrected scores. If the test is being used as a pass/fail criterion, on the other hand, correction for guessing may be necessary. This can be done in two basic ways.

The first is tell the candidates that *wrong* answers will be given negative marks (to discourage guessing), and then to apply the formula:

corrected score = no of correct responses – no of incorrect responses when the test is marked.

The second is simply to apply a standard 'correction for guessing' scaling formula of some sort, the most widely used being the following:

$$\text{corrected score} = \text{no of correct responses} - \frac{\text{no of incorrect responses}}{n - 1}$$

where n is the number of options per item. As can be seen, this second formula reduces to the first in the case of a test consisting of true/false questions (where n = 2).

Further Reading

Readers who require more detailed guidance on how to write, evaluate and use objective questions are referred to the following three general texts:

1. *Objective Testing in Education and Training*, by W Bonney Rust; Pitman Education Library, London; 1973.
2. *Objective Testing*, by H G MacIntosh and R B Morrison; Unibooks, University of London Press; 1969.
3. Constructing Achievement tests, by N E Gronlund; Prentice Hall Inc., Englewood Cliffs, New Jersey; 1968.

For teachers of chemistry, physics and mathematics, the following three subject based texts are also highly recommended.

- *The Principles of Objective Testing in Physics*, by J G Houston.
- *The Principles of Objective Testing in Chemistry*, by C V T Campbell and W J Milne.
- *The Principles of Objective Testing in Mathematics*, by W G Fraser and J M Gillam.

All three books are published by Heinemann Educational Books, London and Edinburgh.